Fermi National Accelerator Laboratory

FERMILAB-Pub-96/361-E

DØ

Beam Test of the SVXII

R. Angstadt et al.

Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

October 1996

Submitted to *Nuclear Instruments and Methods in Physics Research*

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy

Disclaimer

Distribution

Beam Test of the SVXII

R. Angstadt[a], M. Baert[a], L. Cremaldi[c], G. Finocchiaro[e], B. Gobbi[b], Q.P. Jia[b], M.E. Johnson[a], D. Mendoza[a], P. Rubinov[b], G. Sellberg[a], M. Utes[a], Y. Yu[d].

[a] *Fermi National Accelerator Laboratory, Batavia, IL 605510*
[b] *Northwestern University, Evanston IL 60208*
[c] *University of Mississippi, University, MS 38677*
[d] *Seoul National University, Seoul, Korea*
[e] *State University of New York, Stony Brook, NY 11794*

(October 12, 1996)

We report on the performance of the SVXII-B chip and its related readout electronics. This test was carried out in a beam by reading out a telescope of three MSGCs. The electronics used was an early version being developed for readout of the tracking detectors of the DØ experiment.

I. Introduction

The SVXII [1,2] ASIC has been designed to record the information from the silicon microstrip detectors operating as part of the DØ detector at the Fermilab collider. The DØ detector is undergoing an upgrade [3] of its tracking system and will use this chip to digitize and readout its one million silicon channels. In addition the information of the barrel of scintillating fibers and of the preshower detectors (with ≈100,000 channels) will also be recorded using the SVXII chip following the VLPC [4] light sensitive photon counter. The test described here used the -B version of the chip, and was intended to ascertain the basic operation of a completely new system, still under development, rather than to determine its ultimate performance. The SVXII is comprised of 128 identical channels. The main components are an integrating preamplifier which feeds the analog pipeline followed by an 8 bit Wilkenson type ADC. The depth of the pipeline is programmable and can store a maximum of 4 μsec of data in 32 stages. Acquisition of charge from the detectors is possible every 132 nsec, with on chip digitization and zero suppression. A control signal (usually derived from a fast trigger) to the SVXII indicates when pipeline acquisition should stop and readout of the appropriate storage capacitor should begin. The readout of the chip is possible every 8 μsec.

II. Experimental arrangement

This test was carried out at the AGS at BNL in June of 1995. We recorded the information from a telescope of three Micro-Strip Gas Chambers. These chambers had a sensitive area of 32×64 mm^2, and they were built on a substrate of 300 μm thick Desag D-263 glass [5]. The chambers have 120 cathodes subdivided into two equal areas, with anodes 10 μm wide and with a pitch of 200 and 400 μm respectively. Only the information from the 400 μm region has been recorded for this test. The detector drift gap was 3 mm and the chambers were operated with 100% DME. A more detailed description of the detectors used can be found in ref. [6]. For this test, a pion beam (3 GeV/c) with a spill length of about 1 sec occurring every 3 seconds crossed the detectors at a rate of $\approx$ 30 KHz. The beam was detected by a coincidence of scintillation counters which determined the crossing time. The data was readout and recorded at a rate of about 10 Hz. Figure 1 is a block diagram of the readout electronics used in this test. The 120 cathodes of each MSGC are extended to pads (spaced 200 μm apart) at the periphery of the substrate. Here an elastomer connector [7] takes the information from the substrate to a printed circuit board with the SVXII-B. These boards, manufactured at the BNL printed circuits lab, use traces 50 μm wide and spaced by 100 μm to rearrange the input signals for easy microbonding to the chip. An important issue concerning the operation of these types of chips with MSGCs is the concern about potential damage to the chip from breakdowns in the chamber. The SVX chips include input protection diodes, and there are provisions for including larger diodes on the readout board before the chip. In a previous test in which the earlier generation SVXI-H chip was used to record data from MSGC's [8], protective diodes proved unnecessary. However, in this test, after only a brief period of operation (and without any HV trips), a large fraction of traces on the chip between input pad and its protective diodes were destroyed. Additional protective diodes (MMAD130/XAA333) were then added on the board itself, without causing loss of signal nor increase in noise. After this modification no lines on the chip were damaged.

The readout electronics includes three main components: the Port Card, the Silicon Acquisition and Readout board (SAR) and the Silicon Acquisition/Readout Controller (SARC). The preamplifier boards are daisy chained and connected to the Port Card, which is located close to the SVXII chips to minimize the cable length. It acts as a buffer and cable driver for the data and control signals. The signals are transmitted by transceivers through an 8.5 m long twisted pair cable to the SAR board in a VME crate, though this will eventually be an optical link. Here the data are stored in one of several banks of FIFO memories. The FIFOs place their data onto the VME backplane to a VME Buffer Driver (VBD) which stores the event data in buffers for eventual readout to a farm of computers for processing and selection before being stored on tape. The SARC module generates the necessary control signals for the SVXII chip. These signals control the operations of the SVXII chip, such as data-acquisition, digitization, readout, and various resets. The transceivers on the Port Card receives the control codes and drives the control lines of the SVXII chip. Reliable operation of the system was possible at a clock frequency of 31 MHz, limited by the SVXII chips. In the beam test setup, the VME crate housing these modules was monitored with a Bus Analyzer board connected to a PC. The information was readout through a BIT3 board [9,10] by a PC connected via ethernet to a VAX station with a 9GB storage disk.

The SVXII does not have a timed output signal that could be used to set the depth of the pipeline. We consequently used the following procedure to set this depth. A pulser signal was split (near the detectors) and one of them sent to the NIM coincidence unit over the signal cable of one of the scintillation counters. From here it continued to the SARC card (which sets the depth of the pipeline). The other pulser was injected in the SVXII-B (by a capacitive coupling through the traces on the preamplifier board to the chip's inputs) and then it was returned to the readout modules and processed. Pulser data were then recorded with different settings of the pipe line of the SVXII. Test signals were only observed for a setting of the pipeline depth at 6 units.

III. Data Analysis and Results

About 50,000 triggers were collected during the few hours of available beam. The pedestals of the ADCs were measured using a random trigger and the response of the ADCs were tested using a test pulse. Measurements were taken at different HV settings to ascertain that the chambers were fully efficient. The majority of the data were then collected at full efficiency to measure the spatial resolution. The analysis program looks for 'clusters' among the pulse height data of the cathodes. These are defined as one or more channels with a content of at least 3 sigma above the pedestal value. The centroid of a cluster is usually taken as the position of the track crossing the detector. We define a track as an event with three chamber hits along a straight line. Some of the tracks show clusters which have channels with a content below the pedestal value. [1] A similar failure mode is observed in bench tests when the phasing of the clock going to the SAR with respect to the SVX data is slightly off the error-free window. We consequently do not believe that this occasional loss of information was associated with the performance of the SVXII itself. The results presented here are based on selected events for which there are no missing channels within clusters. Figure 2 shows the distribution of the multiplicity of hit channels within single clusters for a 400 μm pitch MSGC

[1] The characteristic of these events are discussed in detail in DØ-Note 3096.

operated at 100% DME. Figure 3 shows the beam profile in one MSGC. The width of the distribution is consistent with the size of the triggering telescope. The position resolution was measured using the standard three point technique as follows. Events with the full cluster information are selected. A straight line is drawn between the centroids of the two outside detectors predicting a hit in the middle chamber. We then plot the distribution of residuals between the centroid in the middle chamber and the position of the extrapolated line. This plot is expected to have a gaussian shape, whose sigma is related to the resolution of the three detectors. Figure 4 shows such a distribution; its sigma is 89 μm. To calculate the resolution from this number one must first subtract the contribution from the multiple scattering and then apply the factor $\sqrt{2/3}$ to account for the resolution of the two outside detectors. The contribution of multiple scattering, calculated using GEANT Monte Carlo, is 10 μm. After these corrections the position resolution is calculated to be 64 μm.

IV. Summary

This very first beam test of the SVXII has shown that it performs as anticipated and so did the related readout electronics. The test also demonstrate that the SVXII can be used to readout MSGCs. The design of the newer versions of the chip has been modified to place the protective diodes right at its input pads. The distribution of the cluster multiplicity as well as the position resolution that we have measured are in agreement with measurements carried out, during the same beam test, on MSGCs with identical geometry but readout using conventional electronics [11].

V. Acknowledgments

We acknowledge the help received from Brookhaven National Laboratory and in particular from Dr. Alan Carroll, David Dayton and the Printed Circuit Laboratory. Fermilab has generously allowed us to use of the lab facilities, and the Physics Dept. MicroDetectors Group has played an essential role. We acknowledge numerous helpful discussions with Dr. Ray Yarema. Research grants from DOE to the participating institutions have made this work possible.

[1] S. Kleinfelder et al., *IEEE Trans. Nucl. Sci.* **NS35** (1988) 171.
[2] Fermilab TM Note 1892, June 1994, R. Yarema et. al.
[3] P.M. Tuts, "The DØ Upgrade". Proceeding of the 3^{rd} International Conference on Advanced Technology and Particle Physics. Como, 22-26 June 1992.
[4] M. Atac et al., *Nucl. Instr. and Meth.* **A320** (1992) 155-160.
[5] Chambers manufactured by IMT, Masken and Teilungen AG, Im Langacher, CH-8606 Greifensee.
[6] N. Amos et al., "Experience and Results from a Beam Test of MSGC's." Proceedings of the International Workshop on Micro-Strip Gas Chambers, Lyon, France. November 30-December 2, 1995, Editors: A. Contardo and F. Sauli.
[7] Fujipoly Inc., 750 Walnut Ave. Cranford, NJ 07016 USA
[8] B. Gobbi et al., "Micro-Strip Gas Chambers R&D at DØ", Proceedings of the International Workshop on Micro-Strip Gas Chambers. Legnaro, Italy. 13-14 October 1994, Editors: G. Della Mea and F. Sauli.
[9] R. Angstadt, M.E. Johnson, M.I. Martin, M.S. Matulik, and M. Utes, **IEEE Trans. Nucl. Sci. NS40** (1993) 1282.
[10] R. Angstadt, F. Borcherding, M.E. Johnson, and L. Moreira, **IEEE Trans. Nucl. Sci. NS43** (1996) 61.
[11] N. Amos et al., Position Resolution of MSGC's with Cathode Readout. Accepted for publication in NIM. FERMILAB-PUB-96/126.

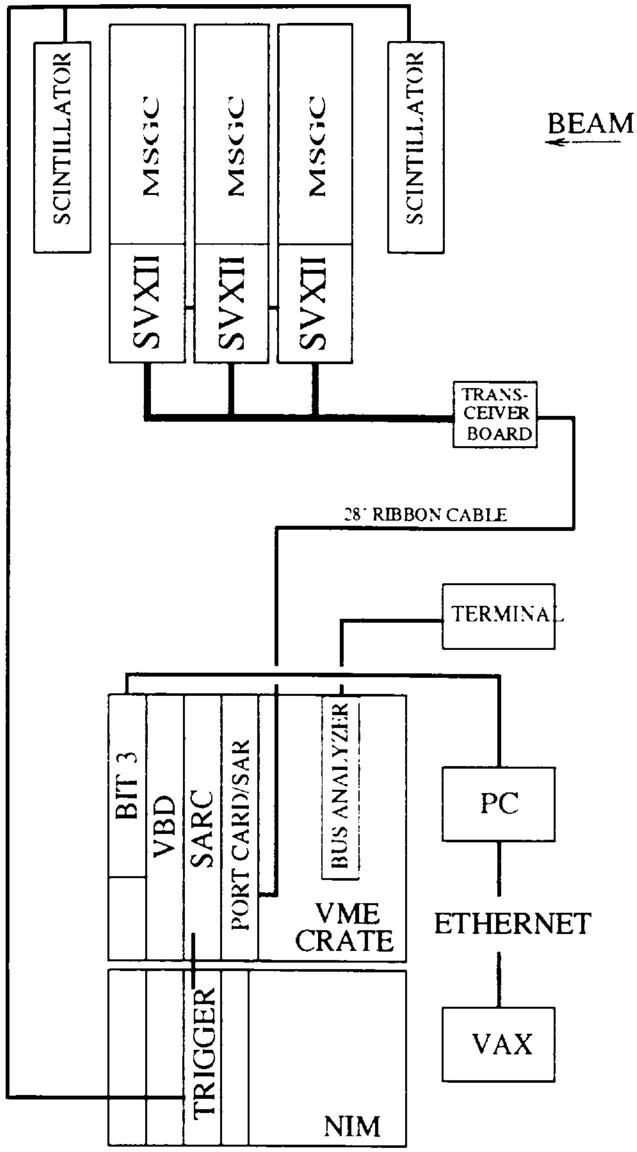

FIG. 1. Block diagram of the readout electronics (see text for details).

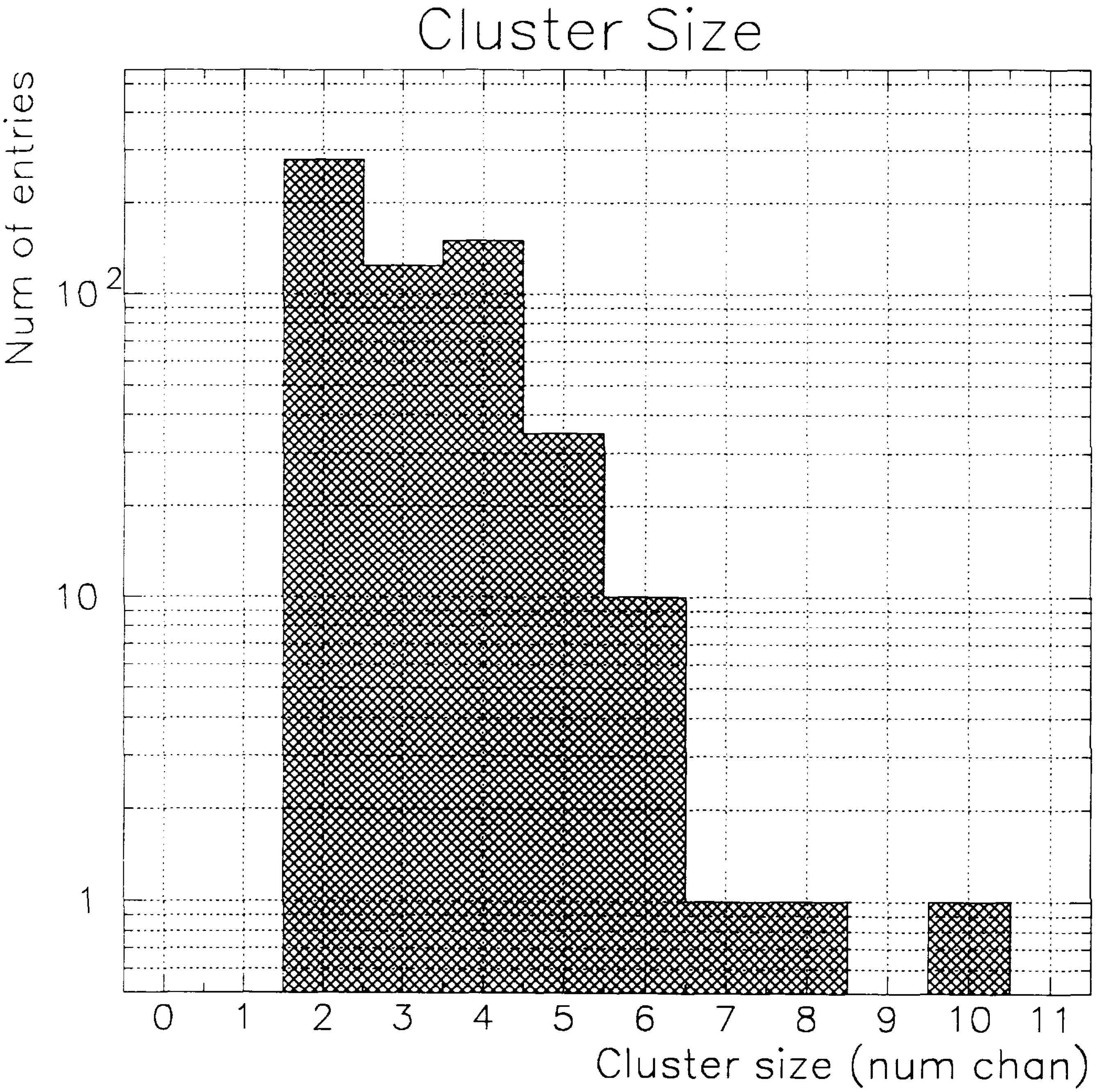

FIG. 2. Distributions of cluster multiplicity, for clusters without missing channels.

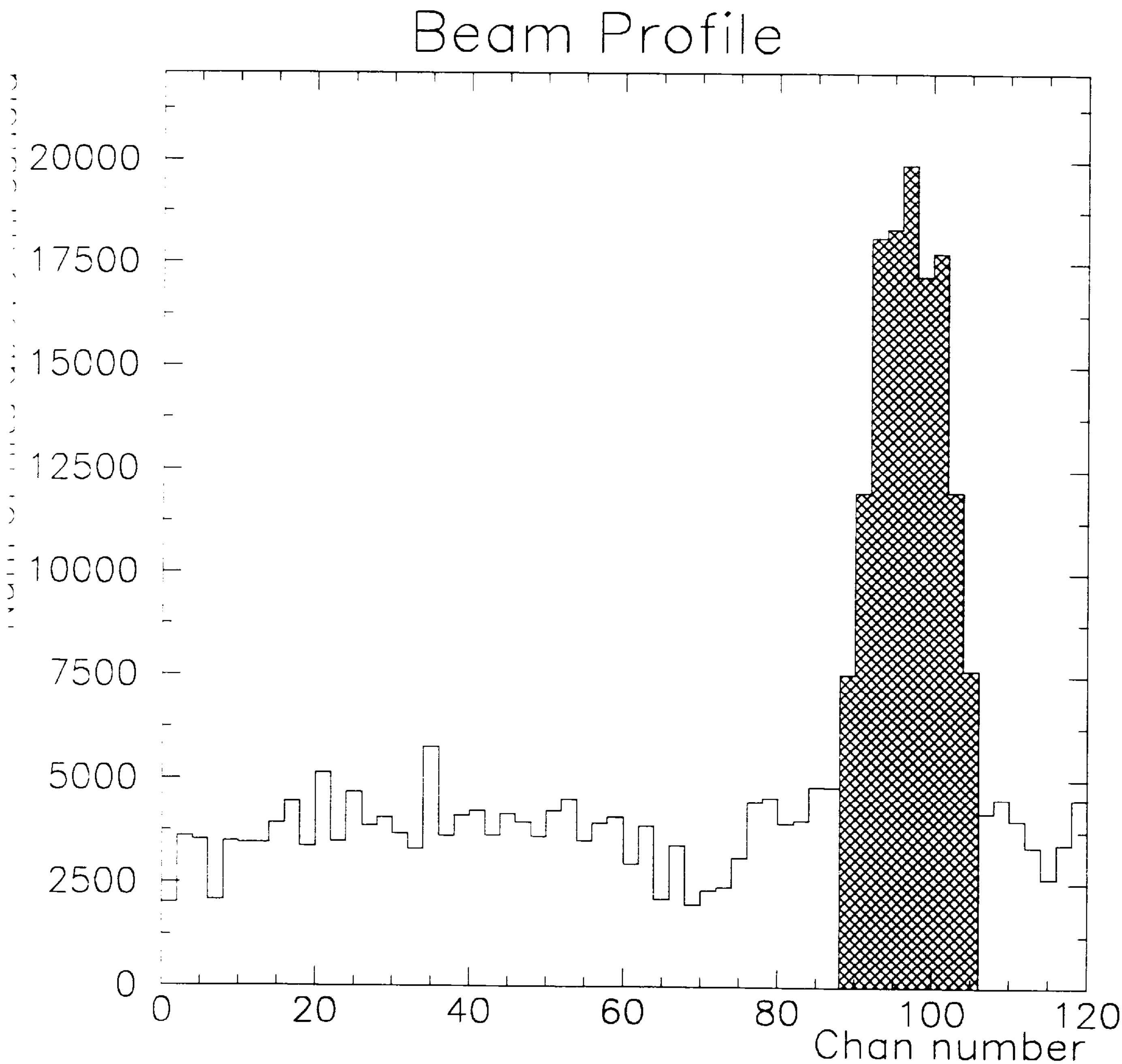

FIG. 3. Distribution of the vertical beam profile measured with a MSGC. No selection of events was done to the data entered in this plot.

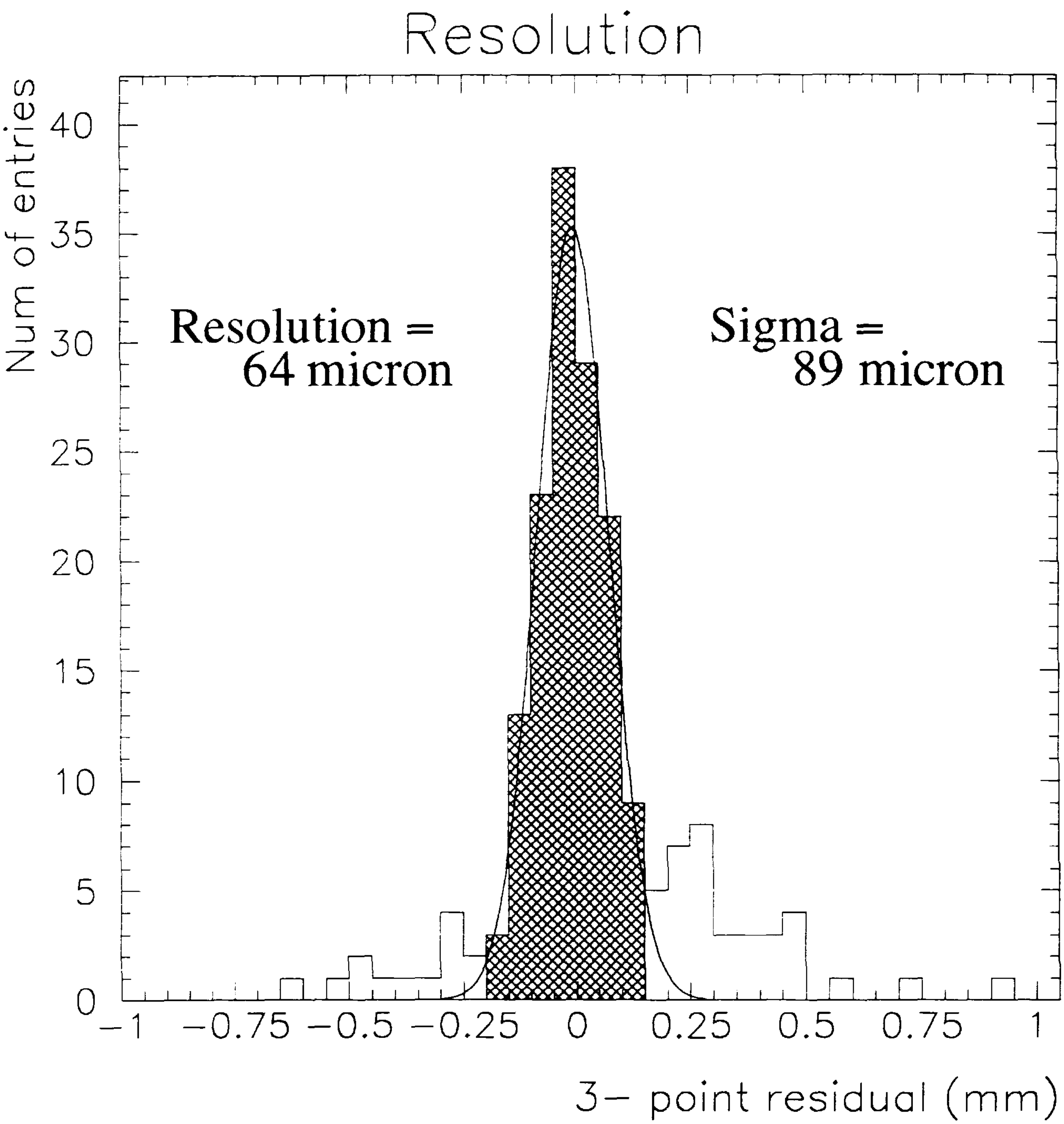

FIG. 4. Distribution of residuals measured with a 400 μm pitch MSGC. (D-263, HV=-2500 V/ + 800 V). The sigma indicates the width of the distribution before corrections. The resolution is deduced from the width by applying corrections for multiple scattering and extrapolation.